Transverse Momentum of ψ and Dimuon Production in Pb+Pb Collisions *

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The NA50 collaboration at the SPS has reported a suppression of ψ production in Pb+Pb collisions relative to Drell-Yan dimuon production as the neutral transverse energy of hadrons, E_T, is increased [1]. They further presented a striking 'threshold effect' by comparing the data to S+U results as a function of the mean path length of the ψ through nuclear matter, L, calculated assuming a sharp-edged nucleus. We point out that the centrality dependence of the transverse momenta of Drell-Yan dimuons essentially provide an experimental determination of L. Such a determination can provide vital evidence for or against the threshold behavior.

Important information can be extracted from the nuclear dependence of the ψ's transverse momentum, p_T. Hadronic suppression [2] does not modify the transverse momentum dependence of ψ production appreciably. To account for the nuclear modification measured in pA and S+U collisions, initial-state parton scattering was introduced [3]. This elastic parton scattering broadens the p_T distributions of charmonium and Drell-Yan production without affecting the p_T-integrated yields. Partons essentially undergo a random walk in momentum space, so that $\langle p_T^2 \rangle$ grows linearly with L.

In a hadron-nucleus collision, a parton from the projectile can suffer soft quasielastic interactions as it crosses the nuclear target [3]. The $\langle p_T^2 \rangle$ of the dimuon or ψ is increased by:

$$\Delta p_T^2 \equiv \langle p_T^2 \rangle - \langle p_T^2 \rangle_{NN} = \lambda^2 (\overline{n}_A - 1), \qquad (1)$$

where $\overline{n}_A$ is the number of NN subcollisions that the projectile suffers in the target, λ^2 determines the p_T^2 increment from each subcollision and $\langle p_T^2 \rangle_{NN}$ is A-independent contribution from the hard scattering.

In a nucleus-nucleus collision, both projectile and target partons scatter,

$$\Delta p_T^2 \equiv \langle p_T^2 \rangle - \langle p_T^2 \rangle_{NN} = \lambda^2 (\overline{n}_A + \overline{n}_B - 2)\,, \quad (2)$$

where the path length is

$$L \equiv (\overline{n}_A + \overline{n}_B)/2\sigma_{NN}\rho_0 \equiv \overline{n}/2\sigma_{NN}\rho_0. \qquad (3)$$

The relation between $\overline{n}$ and the impact parameter $\vec{b}$ depends on the collision geometry.

We expect $\langle p_T^2 \rangle$ to increase by 12.3% for ψ as E_T increases from 50 to 150 GeV. This represents a flattening of $\langle p_T^2 \rangle(E_T)$ in comparison to the S+U $\to \psi + X$ data, which show an 18.5% increase as E_T varies from 30 to 90 GeV. However, we stress that the most direct extraction of L comes not from ψ but from Drell-Yan production since this process is unaffected by final-state interactions. To check that the NA50 extraction of L is correct, Drell–Yan data in Pb+Pb would have to establish a 2.7% increase in $\langle p_T^2 \rangle$. This requires dimuon data far more precise than that for S+U collisions.

The model parameters were revised to describe the latest E772 $p\mathrm{A} \to \mu^+\mu^- + X$ data. Our revision implies a ratio $(\lambda_\psi/\lambda_{\mu^+\mu^-})^2 \sim 3.9$, larger than that extracted earlier, indicating that final-state scattering of the octet $c\overline{c}$ may occur. More precise $p\mathrm{A} \to \psi + X$ measurements are needed to explore this possibility.

[1] M. Gonin *et al.* (NA50), Proc. Quark Matter '96, Heidelberg, Germany, P. Braun-Munzinger *et al.*, eds. (1996).

[2] S. Gavin and R. Vogt, LBL-37980, to be published in Phys. Rev. Lett.

[3] S. Gavin and M. Gyulassy, Phys. Lett. **B214** (1988) 241.

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